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Unity Power Factor for PMSM Drives Fed by MATRIX Converters at the Power Supply Side

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Abstract*: Designing proper characteristics for input filters of matrix converter systems ensures optimized input voltage distortion and decreased high harmonic components in main power supply currents. The input filter works at the power factor operation points which maintain unity. An input filter system allows for improving the power quality in the main supply current. An examination of power factor compensation through the design of an input filter takes place after presenting direct space vector modulation (SVM) switching patterns in this study. The proposed method proves its efficiency through simulated outcomes that utilize a permanent-magnet synchronous motor (PMSM) and an inductive load (RL).*

Keywords*: SVM, PMSM, power factor, Matrix converter*

I. Introduction

An n phase load can be received from an n-phase source by the MATRIX converter (MC) because it operates without energy storage devices (n × m) [1]. In 1979 Peter Wood brought forward the invention of the matrix converter. The basic design of this topology served as a switching matrix. The ac to ac forced commutated converter design by Alesina and Venturini adopted this topology for their creation in future times [2]. In 1980 Alesina and Venturini presented their first matrix converter modulator [3] which did not include unbalanced and harmonic voltage management capabilities. Researchers later brought forward three additional modulation techniques: natural modulation and Rectifier and Inverter Vector Modulation (RIV) [7], [8] followed by Space Vector Modulation (SVM) [4]–[6]. Through the application of these modulations a main network containing harmonics or unbalanced voltages can still create sinusoidal output voltages. All modulation techniques reasonably equivalent to multilevel converters are accessible for MC applications. Helle et al. [10] found that double-sided SVM would reduce switching losses through small vectors or minimum line-to-line input voltages yet this came at the expense of deteriorated input and output current waveforms. Scientists evaluate how system filters affect the input side of power supplies.

Power factor operation at unity needs to be supported by an input filter. The input filter utilizes two main functions to minimize voltage disturbances serving the MC module while it creates high-quality sinusoidal input current. Permanent-Magnet Synchronous Motors or PMSMs have become popular in variable-speed drives which operate in wind systems and electric propulsion and paper and textile industries and other applications [4]. The absence of rotor current during operation in PMSMs increases their efficiency rating above that of induction motors (IM). Removing rotor copper makes it possible to build smaller machines with better power density rates and reduced rotor inertia [5]. Researchers built a direct SVM system to control motor load that relies on how inputs of the MC module are positioned. The formal examination depends on DSVM for conducting theoretical assessments of the method. Subsequent to theoretical analysis of the filter the simulation takes place for enhanced power factor operation at the power source. The researcher conducted tests with a three-phase inductive load and PMSM to confirm theoretical concepts from the study [11].

II. Format Converter using the Direct Method

Figure 1 depicts a three-phase matrix converter with nine completely controlled bidirectional switches that link the input (main) and output (load) phases directly. The issue of changing the frequency of AC electricity can be solved with matrix converters. Generally speaking, the MATRIX converter's attractive features are [6-11]. Current and voltage input and output waveforms are sinusoidal, with no sub-harmonics and few higher order harmonics. The ability to move energy in both directions. The need for energy storage is minimal. A power factor that can be controlled.

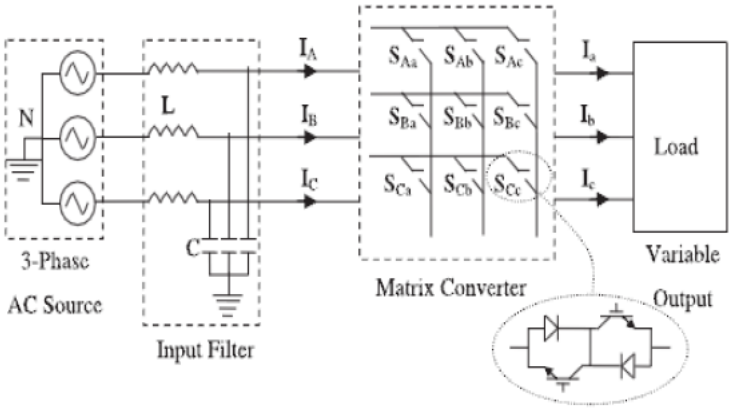

Fig 1: MATRIX converter schematic

Instantaneous power makes it possible to calculate the voltages and currents of one side by using the corresponding values on the other side [7]. The grid-connected MC enables the determination of its input line-to-neutral voltages and output currents due to the load-provided values which subsequently determine the input currents and output line-to-neutral output voltages.

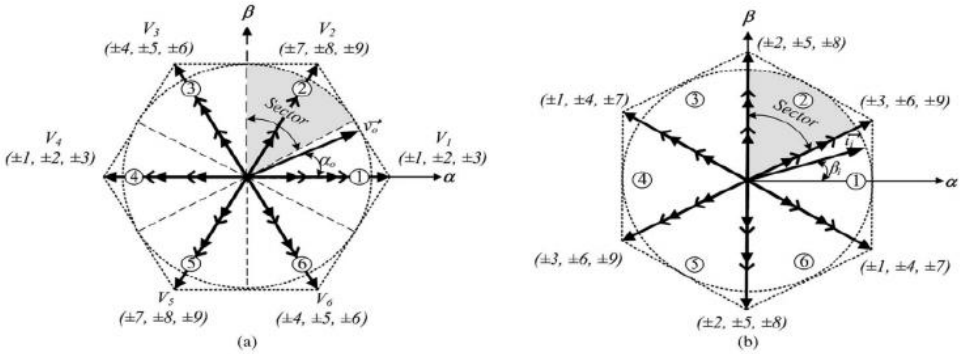

Fig 2: MC vectors. (a) Output voltage vectors. (b) Input current vectors

III. Simulation Result

The simulation environment of MATLAB/Simulink has been used to model both the 3-phase RL load and PMSM system. The RL load simulation settings can be found in Appendix A whereas the PMSM parameters exist in Appendix B. A simulation analysis shows the input-output waveforms of the matrix converter for both cases with and without input filter when feeding an RL load in Figure 3. The installation of an input filter accomplishes the essential purpose of raising the power factor of a matrix converter to unity. Without a filter the matrix converter will show a multitude of high harmonics in its input current. All high harmonic components beyond the filter cutoff frequency can be successfully eliminated by the input filtration system. The study uses an offline-designed input filter incorporated into MC for anytime to extract harmonic elements from the power and stabilize the main power factor. The main

power supply can easily reach unity power factor by connecting to the MC input. This offline approach necessitates a thorough comprehension of the output load power and input power factor [11].

The MC filter with online compensation angle remains compatible with the closed-loop compensation process. Figures 4 represent the input/output waveforms from a matrix converter operating with SVM which includes and excludes the simulated input filter for PMSM application. The down steps perform and the load torque reduces which causes the motor to operate at its rated speed. The main input power follows the fast decline of load torque.

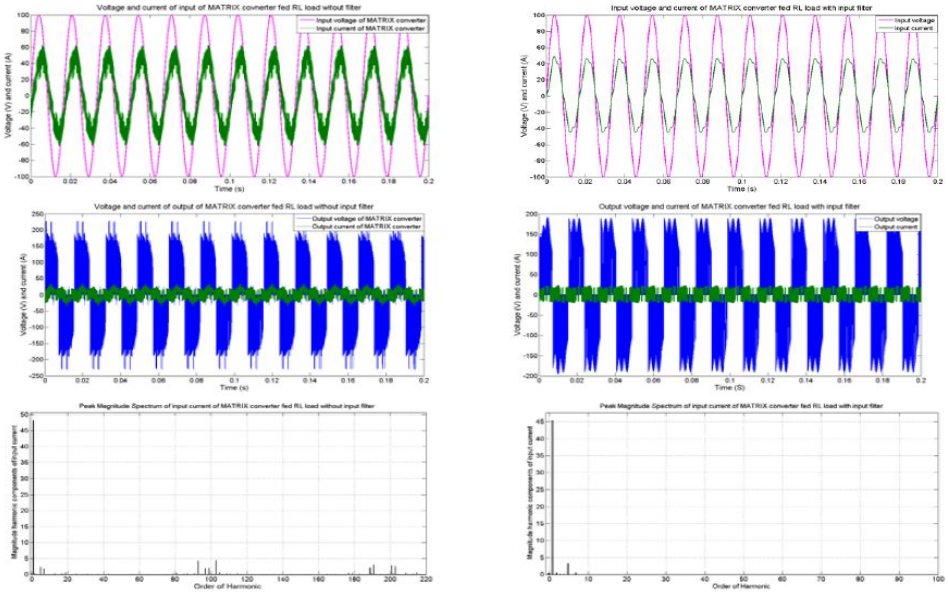

Fig 3: Waveform of voltage and current of MATRIX converter fed RL load

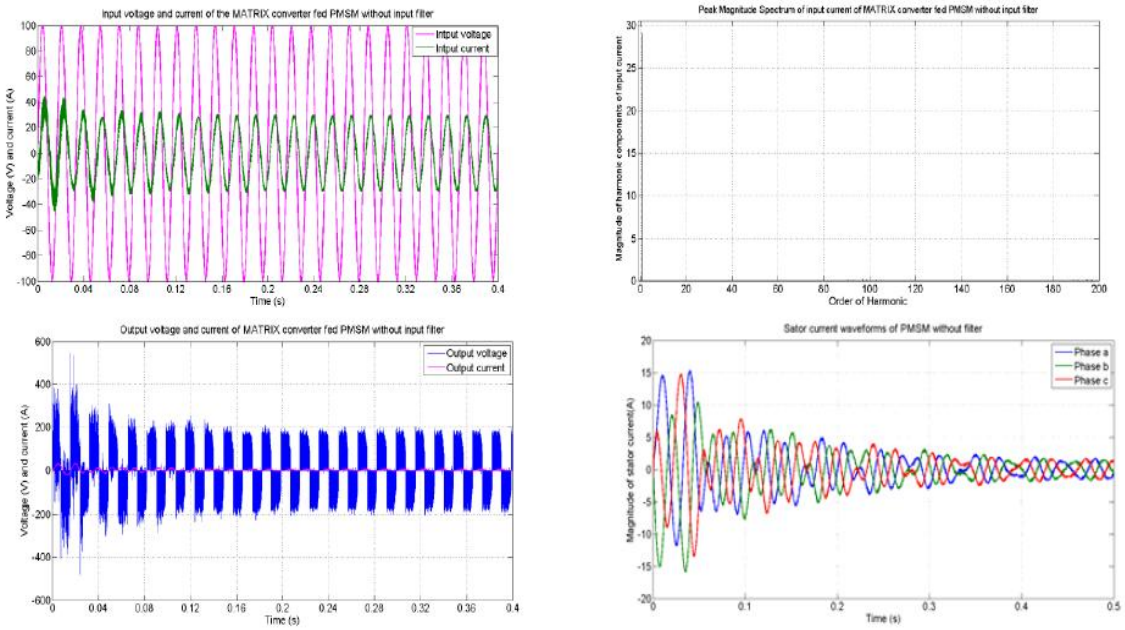

Fig 4: Waveform of voltage and current of MATRIX converter fed PMSM without input filter

III. Conclusion

The paper provides an examination of direct space vector modulation (SVM) for matrix converters which handle RL loads and PMSM derived data. The input side operates near-unity power factor which stands subject to the input filter operation. The power quality improvement process takes place through this method. A performance check of the proposed method shows its effectiveness through simulations that use a permanent-magnet synchronous motor (PMSM) alongside an inductive load (RL).

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